ATTACHMENT A

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Outdoor composting of poultry manure reduces nuisance fly production

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INTRODUCTION

In the animal agriculture industry, disposing of animal wastes in a manner that meets environmental guidelines (mostly those relating to water and air quality) has become more difficult with increasing regulation and litigation (Mullinax et al., 1998). In addition, animal facilities are becoming increasingly surrounded by urban housing whose residents are often quite intolerant of perceived nuisances including flies and odors. The scale of fly production at an animal operation is generally a function of the manure management and sanitation programs at that facility.

Egg-layer poultry houses in California are generally designed as open sided “California Style” houses or more recently, as enclosed environmental houses. With both house designs, poultry manure must be periodically removed. Manure removal may be daily, weekly, or seasonally depending upon the facility design and the successful management of fly production in the manure prior to removal. Following removal from the house, manure is often thin spread to dry (to reduce fly numbers) and then piled for later disposal. This form of manure management is associated with two problems: 1) a very large area is required to spread large volumes of manure to an appropriate 1-3 in depth for rapid drying, and 2) immature flies (maggots and pupae) present in the manure at the time of spreading might be expected to survive and emerge as adult flies.

An alternative method of post-removal manure management is to compost the heavily nitrogenous poultry manure with a carbon source (such as green waste, wood chips, feathers, or dead birds). Composting is a process by which aerobic bacteria are allowed to degrade and decompose the manure and carbon source material producing an end product that would be a good mulch or soil amendment (Mellano and Meyer, 1996). In addition, composting poultry manure with a carbon source will bind the available nitrogen into a stable organic form, making the end product suitable for direct application to crops. Due to its physical properties and ability to readily leach through soil, nitrogen is the largest threat to ground water contamination (Mullinax et al., 1998) and a reduction in nitrogen concentration through composting would be expected to reduce this concern. Volatilization of ammonia from poultry manure, which can result in foul odors, can also be reduced through good compost system management (Paul, 1996).

Composting also reduces the total volume of the starting materials by approximately one-third, thus decreasing the volume of manure that must eventually be moved off of the poultry operation. Handling and spreading of compost is also much easier relative to raw poultry manure which tends to stick in the spreader and clump during field application. Finally, the production of a marketable product (humus or fertilizer) and a reduction in the cost to transport compost as compared to solid or wet manure may make this method of manure management attractive to poultry operations managers.

For proper composting, manure should be mixed with a carbon source and placed into windrows with a height and base width of at least 3 feet to ensure that adequate temperatures (> 130 ºF) are achieved. This high temperature will also prevent the development of flies and will kill immature flies that are already present in the manure before they can emerge as adult flies. The high temperatures are also expected to reduce or eliminate pathogens (virus or bacteria) that may have been present in the poultry manure prior to composting (Atwill, 1997, Mullinax et al., 1998).

Study Rationale:

It is widely assumed that immature flies will not be able to develop in composting material due to the high internal temperature achieved during composting. In addition, it is widely believed that as poultry manure degrades during the composting process, it becomes less able to support developing flies and perhaps will even loose its attractiveness to female flies looking for locations to lay their eggs. However, the production of nuisance flies in composted poultry manure has not been well studied.

For optimal composting, the compost material should have a moisture concentration of 50-60% to encourage bacterial activity but still allow air to reach the core of the compost pile (Mullinax et al. 1998). However, house flies will lay eggs and can complete their larval development on manure with a moisture concentration of 40-70% (Fatchurochim et al. 1989). Similar moisture requirements have been shown for *Fannia* flies (Mullens et al. 2002), which are often a greater nuisance near poultry operations than are house flies.

Since the moisture concentration for optimal composting lies within the range of moisture concentrations suitable for fly development, there was a need to determine if other factors (internal temperature, turning of compost piles, surface drying of the compost windrows, and decomposition of the compost components) related to the process of composting would reduce fly development and survival compared to what might be expected for poultry manure that was not composted.

Study Design:

This study was designed to measure the production of nuisance flies from poultry manure composted with different carbon source amendments. Poultry manure was mixed (1:2 ratio) with municipal green waste or horse bedding containing wood shavings and formed into 30 ft long windrows that were 4 ft high and 8 ft wide along the base. Control treatments included windrows of poultry manure only or green waste only, as well as a non-composting treatment of piled manure covered with a black plastic tarp.

Treatments were randomized into 2 blocks and the study was first conducted during March-April and then repeated in May-June of 2004, giving a total of 4 treatment blocks for evaluation.

Compost treatments were turned with a mechanical compost turner on Tuesday and Friday for the first 2 wks and then only on Tuesday for all remaining weeks. The more frequent turning during the first two weeks was intended to ensure greater control of flies that might be developing in the piles during these first weeks. Flies can develop under optimal conditions in approximately 7 days, and it was expected that with the high temperature and moisture concentration of the compost piles during the first weeks, flies might complete development in the composting material if piles were only turned once per week. Compost windrows were wet as needed (determined by the poultry producer in collaboration with V. Mellano) to maintain an appropriate moisture concentration for proper composting. Wetting occurred by placing garden hose sprinklers on top of the pile and soaking the outer surface of the pile.

Sampling of treatments was conducted on the initial day that compost windrows were constructed, and then every Monday and Thursday over the 4-6 week study period. Sampling consisted of taking a minimum of 20 shallow (< 3 inches from the surface) scoops of each windrow pile using a garden trowel until a sample volume of 4 L was reached. The combined trowel scoops were then thoroughly mixed in a Rubbermaid dish pan to form one relatively homogenous sample, and 500 ml of this sample was removed into a zip-lock bag, placed on wet ice, and returned to the laboratory at the University of California at Riverside to determine the presence of immature flies and the moisture concentration of the compost material on the surface of the windrow. The remaining 3.5 L of the sample was placed into an emergence trap to allow for the continued development and emergence of any immature flies that might have been in the sample.

On each sampling day, the temperature of each treatment pile was also determined using a 3 ft soil thermometer at depths of 3, 5, 10, and 20 inches from the surface of the pile. Temperatures were taken at the midpoint of pile height and length on both the east and west side of each pile, thus providing a high and low temperature at each depth.

RESULTS AND DISCUSSION

Fly Species Present:

Fly species commonly collected during these studies included the house fly (*Musca domestica*), the coastal fly (*Fannia femoralis*), and the black dump fly (*Hydrotaea* sp.). Flies had a species specific preference for the various treatments. House flies were most commonly seen developing in compost piles containing a 2:1 ratio of a carbon source to poultry manure, but were occasionally found in the manure alone compost treatment as well as the tarped manure treatment. *Fannia* flies and *Hydrotaea* flies were most commonly found developing in treatment piles consisting only of poultry manure (manure alone compost treatment and tarped manure treatment). While all of these flies may cause nuisance under some conditions, generally the house fly and *Fannia* fly are the two most problematic for poultry operations (Hinkle and Hickle, 1999). *Hydrotaea* flies rarely cause nuisance and are generally of little concern to poultry operators (though their role in disease transmission is unknown). In fact, *Hydrotaea* can be beneficial as the larvae of this fly are predatory on the larvae of other fly species. This predatory habit can reduce numbers of other flies, like house fly and *Fannia*, which can be significant nuisance pests.

Temperature Measurements:

Temperature measurements throughout the study revealed that the mixing of a carbon source with poultry manure in the presence of sufficient moisture resulted in excellent composting. Temperatures at 10 and 20 inches beneath the surface of the compost piles were consistently 130-160 ºF (54-71 ºC) as expected for material that is properly composting. This high temperature would kill most pathogens and insects. However, temperatures at 3 and 5 inches beneath the surface of the compost piles were often near or below the fly-lethal temperature of 120 ºF (49 ºC). The surface of even very hot compost piles could thus serve as a site for fly development if other characteristics (e.g. moisture content) of this surface material are attractive for egg-laying adult flies.

Two of the four manure only compost treatments never achieved high temperatures even at 10 or 20 inches beneath the pile surface. Likewise, the tarped manure treatments never achieved high temperatures typical of composting. In the absence of a carbon source additive, which also served as a bulking agent, these manure only treatments apparently were unable to undergo composting. The failure to compost was probably due, in great part, to moisture concentrations that were too high to allow air penetration into the pile. Air is needed by the aerobic bacteria responsible for the composting process.

Moisture Concentration Measurements:

Moisture concentration requirements for nuisance flies (40-65% moisture) are about the same as the moisture concentration requirements for efficient composting. This makes sense if we understand that fly larvae feed on bacteria present on manure and other organic material, and that composting or biodegradation of manure and other organic material is caused by bacteria in the composting material. Poultry manure used in these studies had been allowed to build-up beneath poultry cages for several weeks prior to its removal from the poultry houses. Upon removal by scraping and transport to a nearby field for these studies, the manure had a moisture concentration ranging from about 40-60%, in part dependent upon the poultry house from which the manure originated. The incorporation of a carbon source with this manure did not greatly alter the initial moisture concentration for the combined material. However, incorporation of a carbon source (which also served as a bulking agent) and the resulting compost process generally reduced the moisture concentration to < 40% within 7 days, whereas the manure only treatments often retained a moisture concentration > 40% for more than 7 days (manure placed into windrows) or even throughout the entire study (tarped manure).

Nuisance Fly Development:

Immature flies were not found in any treatment with a surface moisture concentration < 40%. All treatments with the exception of the greenwaste only control (no manure added) produced one or more of the common fly species when surface moisture concentration exceeded 40%, regardless of internal temperature conditions within the treatment. Adult egg-laying flies are likely choosing to lay eggs only on material that they perceive to have the necessary moisture content for development of their offspring (Fatchurochim et al., 1989).

Any time moisture was added to the surface of a compost pile (in order to maintain the proper moisture content for composting), immature flies were prevalent at the next sampling period. If the pile was wet enough to keep the surface moisture content above 40% for two sampling periods (minimum of 3 days), then late stage larvae could usually be found. The presence of late stage larvae in a treatment sample was treated as evidence that flies were completing development in that treatment. Late stage larvae would be expected to soon leave the pile and form a puparium within which they would develop into adult flies. If, after wetting a treatment, the surface moisture rapidly (< 3 days) dropped back below 40%, late stage larvae were rarely recovered from subsequent treatment samples.

By the end of this study, it was clear that our method of moisture management (adding water to the pile surface using garden sprinklers whenever the pile appeared to be too dry) was inappropriate for controlling fly development. Piles were often watered for several hours in order to get the water to penetrate into the compost pile, often resulting in a surface moisture content that remained well over 40% for many days or until then next time the piles were turned. A more appropriate means of moisture management might be to wet the pile using any mechanism immediately prior to turning the pile. Turning the pile immediately following the addition of water would spread the moisture more evenly throughout the pile and move much of the very hot material from the pile center to the pile surface. As the surface material cools, it should allow for the evaporation of much of the surface moisture resulting in a surface moisture content < 40% and a core moisture content > 40% allowing for efficient composting. The rapid drop in moisture concentration as the pile surface cools should reduce egg-laying by adult flies as the pile surface would be either too hot or too dry for larval development.

After 1-2 weeks of composting, the presence of immature flies diminished substantially in all of the treatments that contained poultry manure and a carbon source, even when rewetting the compost pile returned the surface moisture concentration to over 40%. Apparently, composting poultry manure with a carbon source results in a material that is either less attractive to egg-laying adult flies or less capable of sustaining larval development. In contrast, the manure only treatments (whether placed into windrows or piled under a tarp) that did not compost (no heat cycles) continued to produce flies for many weeks after initial set-up. In fact, the number of fly larvae increased in some of the manure only treatments during later sampling weeks. This was especially true for the tarped manure treatment where the tarp was lifted by wind or where rips and tears developed due to the recurring sampling of these treatments. It was clear that simply storing manure in piles (tarped or not) did not change the attractiveness of the material for egg-laying flies and as soon as flies could gain access to the material, they would lay eggs on it.

Overall, composting of poultry manure proved to be a very effective means of reducing the production of nuisance flies in poultry manure relative to what would have been expected from alternative methods. After 4-6 weeks of composting, there was also a notable decrease in pile size (to perhaps half the original volume) which would result in a reduction in transport costs to remove the material from the poultry operation. Transport and sale of composted manure is also certainly preferable to the transport and cost of disposing of non-composted poultry manure.

It is our recommendation that composting of poultry manure with municipal greenwaste be encouraged by poultry operators in order to reduce the production of nuisance flies typically associated with the management of animal manures.

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